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GUIDE ON MAINTAINABILITY OF EQUIPMENT

PART II MAINTAINABILITY REQUIREMENTS IN SPECIFICATIONS AND CONTRACTS

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GUIDE ON MAINTAINABILITY OF EQUIPMENT

PART II MAINTAINABILITY REQUIREMENTS IN SPECIFICATIONS AND CONTRACTS

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Indian Standard

GUIDE ON MAINTAINABILITY OF EQUIPMENT

PART II MAINTAINABILITY REQUIREMENTS IN SPECIFICATIONS AND CONTRACTS

0. FOREWORD

0.1 This Indian Standard (Part II) was adopted by the Indian Standards Institution on 29 December 1980, after the draft finalized by the Reliability of Electronic and Electrical Components and Equipment Sectional Committee had been approved by the Electronics and Telecommunication Division Council.

0.2 This guide is intended to make recommendations for the standardization of maintainability practices, and to stimulate ideas in the maintainability field. Organizations acquiring items will find the guide useful in assisting them in defining maintainability requirements and associated programmes. Item suppliers will benefit from use of the guide, gaining an understanding of the requirements for achieving and verifying maintainability objectives.

0.3 The other parts of this standard will be as follows:

Part I	Introduction to maintainability
Part III	Maintainability programme
Part IV	Test and diognostic procedures
Part V	Maintainability design studies
Part VI	Maintainability verification
Part VII	Collection, analysis and presentation of data related to maintainability.

0.4 In the preparation of this standard, assistance has been derived from IEC Document 56 (Central Office) 69 Draft—'Guide on maintainability of equipment: Part II Maintainability requirements in specifications and contracts' issued by the International Electrotechnical Commission.

0.5 This standard is one of a series of Indian Standards on reliability of electronic and electrical components and equipment. A list of standards published so far in this series is given on page 10.

1. SCOPE

1.1 This standard (Part II) covers the general aspects that have to be considered when maintainability characteristics are included as requirements on the development or the acquisition of an item.

NOTE — This standard (Part II) is not intended to be a complete guide on how to specify or to contract for maintainability.

2. GENERAL

2.1 Maintainability is a characteristic defining inherent properties of an item and the corresponding discipline is concerned with how well an item may be maintained and supported during its use period. Maintainability shall be built into the item during the design and development phase and thus it is important that maintainability requirements be established as part of the initial item specification.

2.2 The development of an item may be thought of as a process evolving from a need for a certain function, all the way through a step-by-step definition of that item satisfying the same need, ending up with an item ready for operational use. The process shall be controlled in order to result in an item satisfying needs at the right instant of time and at a reasonable cost. This concept is valid independent of whether a new item is actually designed or a specific need is transferred into a selection of an off-the-shelf item.

2.3 The maintainability requirements in a specification may contain either quantitative or qualitative requirements or both. The methods for verifying that the requirements have been satisfied should be stated. The existence of special constraints which might affect the item's maintainability characteristics should also be stated.

3. MAINTAINABILITY REQUIREMENTS

3.1 A complete statement of maintainability requirements will cover four broad areas:

a) Maintainability characteristics to be achieved by the item design;

b) Constraints to be placed on the item deployment which will affect its maintenance;

c) Maintainability programme requirements to be accomplished by the supplier to assure that the delivered item has the required maintainability characteristics; and

d) Provision of maintenance support planning.

3.2 The maintainability specification should detail the requirements and the method to be followed to achieve them. It should also include proper references to definitions of terms used in the specification and as needed in a list of special terms.

3.3 The specification may be stated as goals or in terms of firm requirements which shall be verified in accordance with prescribed procedures. Goals or requirements may be stated in either quantitative or qualitative terms.

NOTE — In this standard a 'goal' is considered as a desirable feature which is not mandatory whereas a requirement shall be provided.

3.4 A maintainability specification typically covers the various aspects of maintainability achievement at the operational level. However, since maintainability as an item characteristic affects maintenance and support costs and may also affect maintenance times at different maintenance levels, statements should be included in the specification covering achievements needed at all levels affected by the maintenance policy.

3.5 Maintainability Characteristics

3.5.1 *Quantitative Maintainability Requirements* — The most common objective is related to the time for which an item is in a non-operable status due to maintenance. Obviously, one would like to keep this time as short as possible. There is a wide range of requirements that could be used to this effect. The difference between them will be that they express different priorities between related item properties and that they allow for different flexibility concerning trade-offs to be made later in the programme. It is important that such factors are considered before a specific requirement is included in the specification.

3.5.1.1 Active repair time is often used to specify maintainability and includes the following sub-elements:

a) Diagnosis (failure detection, localization of cause, etc);

b) Technical delays (typical technical delays include setting time, cooling, interpretation and application of information, interpretation of displays, read out, etc);

c) Restoration (disassembly, intercharge, reassembly, alignment, etc); and

d) Final check (testing procedures as necessary).

Avariety of other maintainability characteristics may be specified for the item. Table 1 outlines some other types of requirements associated with different classes of maintenance time and verification methods.

TABLE 1 EXAMPLES OF QUANTITATIVE MAINTAINABILITY REQUIREMENTS

(*Clause* 3.5.1.1)

SL No.	TERM	CHARACTERISTICS	VERIFICATION METHOD
(1)	(2)	(3)	(4)
i)	Active maintenance time	Mean, Median or Maximum (*)	Design evaluation, demonstration or operational evaluation
ii)	Active repair time (corrective)	Mean, Median or Maximum (*)	Design evaluation, demonstration or operational evaluation
iii)	Active preventive maintenance	Mean, Median or Maximum (*)	Design evaluation, demonstration or operational evaluation
iv)	Routine inspection interval	Value	Design evaluation, operational evaluation
v)	Maintenance cost per operating hour (†)	Mean	Design evaluation, operational evaluation
vi)	Number of personnel per maintenance action (†)	Mean	Design evaluation, operational evaluation
vii)	Maintenance support cost for life cycle (†)	Mean	Design evaluation, operational evaluation

*The maximum value shall be associated with a percentile — a commonly used value is 95 percent.

†Other time bases may be selected as appropriate, that is, day, month, year, etc.

3.5.2 *Qualitative Maintainability Requirements* — A second achievement to look for is related to the degree to which the item concurs to a specific maintenance and support policy. Where the qualitative requirement contains numerical values, it should be qualified by a statement of the degree to which it should be met. This could be done by proportions of cases or events, by confidence levels or by other probabilities. Otherwise, compliance shall be judged by inspection or document review of standard. Such policies may include statements such as the following examples:

a) Repair shall be performed by personnel of stated skill level;

b) Repair shall be performed by replacement of recoverable units;

c) Replaceable parts shall be plug-in units;

d) Maintenance shall be performed according to defined and established procedures; and

e) Failed part isolation shall be performed by built-in test equipment for 95 percent of all cases.

Appendix A presents a range of other possible qualitative subjects for which requirements may be specified.

3.6 Constraints

3.6.1 When writing a specification, not only should the requirements be stated on how things should be done, but in most cases there are also constraints on ways of meeting requirements which for various reasons may not be accepted (for example, no preventive maintenance may be allowed during certain periods of time). Failure to specify constraints might give the designer the opportunity to fulfil his maintainability requirements at the expense of the user of terms of more expensive instrumentation, etc.

3.6.2 Constraints needed in a specification depend on the nature of the maintainability requirements discussed in **3.5**. It is advisable explicitly to examine this need for each objective stated. Generally such constraints may include a basic maintenance and support policy together with limits for critical resources like expensive instrumentation, high cost spares, and skill and number of personnel at each level in the organization. Some statement putting requirements on the amount and the nature of preventive maintenance may often be included in the specification. Special emphasis shall be given to constraining critical resources to be held on site. Emphasis shall also be given to constraining periods of time, relative to expected utilization of the equipment, when preventive maintenance may be carried out. Constraints may also be introduced by reference to relevant Indian Standards.

3.7 Programme Requirements — There are several reasons why a specification should include requirements for a formal maintainability programme to be used by the supplier in his efforts to satisfy requirements:

a) It facilitates co-ordination between several suppliers delivering items to be used in the same system;

b) It may establish an interface between item development and the development of a maintenance and support system;

c) The customer-supplier interaction defined by a programme might be looked upon as part of a verification that requirements have been fulfilled; and

d) More flexibility for trade-offs may be allowed with a formal programme requirement.

Specific details on maintainability programmes are given in IS : 9692 (Part III)-1981*.

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*Guide on maintainability of equipment: Part III Maintainability programme.

3.8 Engineering Support Planning — To get a cost-effective system it is not sufficient to acquire an item satisfying the requirements. A maintenance and support system shall also be designed to fit the situation. Resources needed to maintain and support the system shall be acquired. This task shall as far as possible be integrated with the acquisition of the equipment to be supported. This may be achieved in the following two ways or by a combination of them:

a) The supplier is given the responsibility of providing some of the resources needed to fulfil maintenance requirements, for example, training, manuals, test equipment, spares, etc.

b) The supplier is given the responsibility of providing, according to a schedule, engineering support planning data, such as:

   i) Failure rates and repair times

   ii) List of special tools and instrumentation

   iii) List and cost of spares

   iv) Test specifications

   v) Training requirements

Maintenance support data are generally developed by means of maintenance engineering and support analysis.

4. VERIFICATION

4.1 Verification of maintainability requirements is the process of determining that the requirements imposed in the specification have been achieved and the verification process should be defined in the maintainability requirements. Methods of verification may range from the submission by the supplier of appropriate data or information to a requirement to perform a special maintainability demonstration. IS : 9692 (Part VI)* gives in some detail the alternative verification methods.

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*Guide on maintainability of equipment: Part VI Maintainability verification (*under preparation*).

APPENDIX A

(*Clause* 3.5.2)

EXAMPLES OF QUALITATIVE SUBJECTS FOR WHICH REQUIREMENTS MAY BE SPECIFIED

i) Maintenance skill level requirements.

ii) Need for special tools or test equipment.

iii) Need for adjustments.

iv) Parts standardization.

v) Clear subsystem function identification.

vi) Visual inspection access.

vii) Built-in test facilities.

viii) Properly marked test points.

ix) Colour coding and labels as appropriate.

x) Use of plug-in units.

xi) Use of captive fasteners.

xii) Use of handles on replaceable units.

xiii) Scope and range of technical manuals.

xiv) Human factor limitations in the design of the item.

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ON

RELIABILITY OF ELECTRONIC AND ELECTRICAL COMPONENTS AND EQUIPMENT

IS:

1885 (Part XXXIX)-1979 Electrotechnical vocabulary: Part XXXIX Reliability of electronic and electrical items (*first revision*)

2612-1965 Recommendation for type approval and sampling procedures for electronic components

7354 Guide on reliability of electronic and electrical items:

- Part I-1975 Part I Preliminary reliability considerations
- Part II-1975 Part II Managerial aspects of reliability
- Part III-1975 Part III Presentation of reliability data on electronic and electrical components (or parts)
- Part IV-1974 Part IV Collection of reliability, availability and maintainability data from field performance
- Part V-1975 Part V Inclusion of lot-by-lot and periodic inspection procedures in specifications for electronic and electrical components (or parts)
- Part VI-1975 Part VI Inclusion of reliability clauses into the specifications for components (or parts)

7690-1975 Mathematical guide to the terms and definitions for reliability of electronic equipment and components (or parts) used therein

8161 Guide for equipment reliability testing:

- Part I-1976 Part I Principles and procedures
- Part VII-1977 Part VII Compliance test plans for failure rate and mean time between failures assuming constant failure rate

9185 Endurance (life) test for electronic and electrical components:

- Part I-1979 Part I Thermal endurance
- Part II-1979 Part II Mechanical endurance

9186-1979 Guide for screening of electronic and electrical items